BlueMarble Science Processing Algorithm (BLUEMARBLE_SPA) User's Guide

Version 1.8

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GODDARD SPACE FLIGHT CENTER
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Table of Contents

BlueMarble Science Processing Algorithm
BLUEMARBLE_SPA

1. General

The NASA Goddard Space Flight Center's (GSFC) Direct Readout Laboratory (DRL), Code 606.3 developed this software for the International Polar Orbiter Processing Package (IPOPP). IPOPP maximizes the utility of Earth science data for making real-time decisions by giving fast access to instrument data and derivative products from the Joint Polar Satellite System (JPSS), Suomi National Polar-orbiting Partnership (SNPP), Aqua, and Terra missions.

Users must agree to all terms and conditions in the Software Usage Agreement on the DRL Web Portal before downloading this software.

Software and documentation published on the DRL Web Portal may occasionally be updated or modified. The most current versions of DRL software are available at the DRL Web Portal:

https://directreadout.sci.gsfc.nasa.gov/?id=software

Questions relating to the contents or status of this software and its documentation should be addressed to the DRL via the Contact DRL mechanism at the DRL Web Portal:

https://directreadout.sci.gsfc.nasa.gov/?id=dspContent&cid=66

2. Algorithm Wrapper Concept

The DRL has developed an algorithm wrapper to provide a common command and execution interface to encapsulate multi-discipline, multi-mission science processing algorithms. The wrapper also provides a structured, standardized technique for packaging new or updated algorithms with minimal effort.

A Science Processing Algorithm (SPA) is defined as a wrapper and its contained algorithm. SPAs will function in a standalone, cross-platform environment to serve the needs of the broad Direct Readout community. Detailed information about SPAs and other DRL technologies is available at the DRL Web Portal.

3. Software Description

The BlueMarble SPA software package can create MODIS sharpened True Color and Natural Color imagery; VIIRS sharpened True Color and Natural Color imagery; VIIRS Enhanced Near Constant Contrast (ENCC) day and night imagery; and overlays of Ozone Mapping Profiler Suite (OMPS) SO2 and OMPS Ultraviolet Aerosol on True Color, Natural Color or ENCC geotiff imagery. BlueMarble also allows overlays of fire location pixels and shapefiles on these image products. The True Color, Natural Color and ENCC image products can be used in various Earth science disciplines to visualize Earth features, track environmental phenomena, and as background images to provide more context to other Earth science data overlaid on them (such as the OMPS and fire pixel overlays). The SPA

functions in two modes: Standalone, or as an IPOPP plug-in (IPOPP v2.6 and later).

BlueMarble offers users the following features and capabilities:

- **Sharpened True Color and Natural Color Imagery:** BlueMarble employs a sharpening technique to enhance the True Color and Natural Color (a Shortwave-Infrared [SWIR]/Near Infrared [NIR]/Red False Color RGB) imagery. Sharpening involves creation of high resolution reflectances (250m for MODIS, 375m for VIIRS) from corresponding moderate resolution reflectances (500m for MODIS, 750m for VIIRS) by using the relationships between (i) the moderate and high resolution reflectance bands, and (ii) moderate and high resolution scan geometry.

- **VIIRS-DNB based ENCC Day/Night Imagery:** BlueMarble produces VIIRS-DNB based day/night/twilight imagery using ENCC products as input. ENCC products can be generated by the ENCC SPA. Please contact the DRL for additional information regarding the ENCC SPA.

- **Fire Location Overlays:** BlueMarble supports overlays of fire locations (as generated by MOD14, VIIRS-AF and VFIRE375 SPAs; available via the DRL Web Portal) on any BlueMarble-generated geotiff imagery. Users can choose the fire pixel marker size and type. BlueMarble also includes a capability to cluster fire pixels, compute cluster perimeters and overlay the computed fire perimeters on image products.

- **OMPS SO$_2$ and Aerosol Overlays:** BlueMarble allows overlays of OMPS SO$_2$ and OMPS Aerosol products on any BlueMarble-generated geotiff imagery. BlueMarble automatically determines the projection, location and spatial dimensions of the input background geotiff, searches for OMPS products that overlap the location, and overlays the OMPS products on the background geotiff. Users can select the transparency, parameter-range and filtering level (for smoothing) of the overlays. Companion legends are also produced.

- **Shapefile Overlays:** BlueMarble supports overlays of vector shapefiles on the image products. Multiple shapefiles (such as high resolution coastlines, US states, rivers and counties) are included in the package.

- **User-defined Projection and Resolution:** BlueMarble allows users to select different projections (currently stereographic and geographic are available) and resolution.

- **User-defined Region-of-Interest (ROI) or Swath Imagery :**BlueMarble allows users to specify Regions-Of-Interest (ROIs) for their output imagery. ROI extents can range from local to regional to global. ROI image products offer a constant spatial frame of reference and are very useful in tracking environmental phenomena, such as volcanoes, fires or floods over time. In absence of an user-defined ROI, BlueMarble produces swath imagery.

- **Automatic Subsetting and Mosaicing to Produce ROI Imagery:** BlueMarble automatically subsets and mosaics products to produce ROI imagery.

- **Automatic Search of Input Products that Overlap an ROI:** BlueMarble can automatically search through sets of input files to identify and process only those inputs that overlap with the specified ROI.

- **Attention to Imagery Quality:** BlueMarble implements various quality control techniques in order to produce images with the highest quality. These techniques address issues related to input data quality, interpolation strategies, direct broadcast dropouts/partial scans, bowtie effects and scan edges. For example, BlueMarble uses preceding and succeeding granules to produce images for the primary granule so that quality does not degrade at the granule start/end edges. Both single granule and multi-granule inputs are supported.

- **Generation of GIS-ingestible Geotiff Products**: BlueMarble creates the image products in geotiff format. The geolocated GeoTIFF images are Geographic Information System (GIS)-ingestible and can also be opened by standard image viewers. Users can easily convert geotiff imagery into any other image format using standard image processing tools.

4. Software Version

Version 1.8 of the DRL algorithm wrapper was used to package the software package described in this document. The SPA uses BlueMarble processing code (Version 1.8, June 2017).

Enhancements to this SPA include:

- Support for generating imagery from ENCC products. Contact the DRL for more information regarding the ENCC SPA.

- MODIS and VIIRS Natural Color and VIIRS ENCC imagery generation capability in IPOPP Mode. The SPA service architecture for generating MODIS and VIIRS True Color imagery in IPOPP Mode has been modified by adding new SPA services that produce intermediate Sharpened Corrected Reflectance True Color products.

- Simplified command line interface for OMPS SO_2 and Aerosol imagery generation, including greater flexibility for choosing preferred background image (e.g., True Color, Natural Color, ENCC) for the OMPS overlay.

- New features to create imagery tailored to a specific natural event. The OMPS imagery module now includes: (i) capability to use any BlueMarble geotiff as background (ii) capability to select parameter range (iii) capability to control smoothing level and overlay transparency (iv) capability to generate legends. (v) capability to choose SO_2 fields to focus on different atmospheric levels.

- Improved OMPS Aerosol and SO2 resampling techniques for more accurate overlays of the low resolution OMPS data on higher resolution backgrounds. (OMPS overlay imagery, including the defaults, may appear different from imagery generated using BlueMarble v1.5.)

- Removed mosaic gaps previously visible in some MODIS and VIIRS imagery.

This software will execute on a 64-bit computer. This software has been tested on a computer with 32GB of RAM and a CentOS Linux 7 x86_64 operating system.

5. Credits

BlueMarble was developed by the DRL at NASA/GSFC. The sharpening techniques utilized in the SPA are described in:

[1] Gumley, L., Descloitres, J., & Schmaltz, J. "Creating Reprojected True Color MODIS Images: A Tutorial," Version 1.0.2, 14 January, 2010.

[2] Direct Readout Laboratory (NASA/GSFC). "Creating Reprojected True Color VIIRS Images: A Tutorial", Version 1.0, 14 May, 2015.

6. Prerequisites

To run this package, you must have the Java Development Kit (JDK) or Java Runtime Engine (JRE) (Java 1.6.0_25or higher) installed on your computer, and have the Java installation bin/ subdirectory in your PATH environment variable. We recommend at least 16GB of RAM for running BlueMarble. The BlueMarble software package uses the ImageMagick utility to mosaic image products. ImageMagick must thus be installed and available on your computer. You may use the Linux package manager on your machine to install ImageMagick, if it is not already available on your computer (e.g., "yum install ImageMagick" or "sudo apt-get install imagemagick"). Otherwise please refer to http://www.imagemagick.org for instructions to download and install ImageMagick.

7. Program Inputs and Outputs

For VIIRS True Color and Natural Color, BlueMarble takes the VIIRS Imagery Resolution Corrected Reflectance product, VIIRS Moderate Resolution Corrected Reflectance product (only for True Color), and VIIRS I-Band Terrain Corrected Geolocation (GITCO) product as input and produces a sharpened VIIRS True Color or Natural Color image product.

For VIIRS ENCC, BlueMarble takes the VIIRS ENCC product as input and produces a VIIRS ENCC image product.

For MODIS True Color and Natural Color, BlueMarble takes the MODIS Level 1B 1km (MOD021KM/MYD021KM), Level 1B 500m (MOD02HKM/MYD02HKM), Level 1B 250m

(MOD02QKM/MYD02QKM) and the MODIS Geolocation (MOD03/MYD03) products as input and produces a sharpened MODIS True Color or Natural Color image product.

OMPS SO$_2$ and Aerosol overlays on BlueMarble geotiffs require the OMPS Total Column Total SO$_2$ Near Real-time (NRT) and OMPS Total Column Total Ozone products (both available from OMPSNADIR_SPA v2.0.1b or later) as input.

Fire pixel and perimeter overlays on the geotiffs require the fire location text files generated by the MOD14_SPA (for MODIS) and VIIRS-AF_SPA or VFIRE375_SPA (for VIIRS) as input.

Shapefile overlays on the geotiffs require vector shapefiles as input. Multiple shapefiles (such as high resolution coastlines, US states, rivers and counties) are included in the package.

8. Installation and Configuration

8.1 Installing as a Standalone Application:
Download the BLUEMARBLE_1.8_SPA_1.8.tar.gz and
BLUEMARBLE_1.8_SPA_1.8_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the BLUEMARBLE_1.8_SPA_1.8.tar.gzand
BLUEMARBLE_1.8_SPA_1.8_testdata.tar.gz(optional) files:

$ tar -xzf BLUEMARBLE_1.8_SPA_1.8.tar.gz
$ tar -xzf BLUEMARBLE_1.8_SPA_1.8_testdata.tar.gz

This will create the following subdirectories:
    SPA
        BlueMarble
            algorithm
            ancillary
            mode
            station
            testdata
            testscripts
            wrapper

8.2 Installing into an IPOPP Framework

NOTE: BlueMarble's IPOPP Mode is supported in IPOPP v2.6 and later.

This SPA can also be installed dynamically into an IPOPP framework to automate production of VIIRS and MODIS True Color and Natural Color imagery, as well as VIIRS ENCC imagery. The SPA installation process will install its SPA service(s) into IPOPP. An SPA service is an IPOPP agent that provides the mechanism necessary for running an SPA automatically within the IPOPP framework. Once this SPA is installed, users must configure

the SPA and enable the SPA service(s) corresponding to this SPA along with any other prerequisite SPA service(s). Instructions for installing an SPA and enabling its services are contained in the IPOPP User's Guide (available on the DRL Web Portal). The SPA services associated with this SPA are listed in Appendix A.

9. Software Package Testing and Validation

The testscripts subdirectory contains test scripts that can be used to verify that your current installation of BlueMarble is working properly, as described below. Note that the optional BLUEMARBLE_1.8_SPA_1.8_testdata.tar.gzfile is required to execute these testing procedures.

Step 1: cd into the testscripts directory.
Step2: There is a script named run-BlueMarble_viirs-tcolor.sh inside the testscripts directory.
To run the BlueMarble algorithm and create sharpened VIIRS True Color images, use

    $./run-BlueMarble_viirs-tcolor.sh

A successful execution usually requires about 3 minutes or more, depending on the speed of your computer. If everything is working properly, the scripts will terminate with a message such as:

Done: outputs are at ../testdata/output/viirsoutput

NOTE: Warnings about previous and next files being missing are expected. BlueMarble does not find them because they are not included in the testdata tarball.

You can cd to the output directory to verify that the image products exist in the location specified. Test output product(s) are available for comparison in the testdata/output directory. These test output product(s) were generated on a 64-bit PC architecture computer running CentOS 7.The output products serve as an indicator of expected program output. Use a comparison utility (such as a standard image viewer) to compare your output product(s) to those provided in the testdata/output directory. Locally generated files may differ slightly from the provided output files because of differences in machine architecture or operating systems.

If there is a problem and the code terminates abnormally, the problem can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However, it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. Please report any errors that cannot be fixed to the DRL.

10. Program Operation

BlueMarble supports the following operations:

1. Creating Swath/ROIVIIRS True Color Geotiffs

2. Creating Swath/ROI MODIS True Color Geotiffs

3. Creating Swath/ROI VIIRS Natural Color Geotiffs

4. Creating Swath/ROI MODIS Natural Color Geotiffs

5. Creating Swath/ROI VIIRS ENCC Day/Night Geotiffs

6. Creating OMPS-SO2 Overlays on BlueMarble Geotiffs

7. Creating OMPS-Aerosol Overlays on BlueMarble Geotiffs

8. Overlay fire pixels and perimeters on BlueMarble Geotiffs

9. Overlay Vector Shapefiles on BlueMarble Geotiffs

The following subsections describe the BlueMarble scripts that are to be used for each of the listed operations. Note that to execute the scripts, you need to have Java on your path and ImageMagick installed on your computer.

To execute the BlueMarble scripts, you must supply the required input and output parameters. Input and output parameters are usually file paths or other values (e.g., the projection of the output image). Each parameter is specified on the command line by a <label value> pair. Labels are simply predefined names for parameters. Each label must be followed by its actual value. Each process has its own set of <label value> pairs that must be specified in order for it to execute. Some of these pairs are optional, meaning the process would still be able to execute even if that parameter is not supplied. The three types of <label value> pairs that BlueMarble uses are:

a) Input file label/values. These are input file paths. Values are absolute or relative paths to the corresponding input file.

b) Output file label/values. These are output files that are produced by the SPA. Values are absolute or relative paths of the files you want to generate.

c) Parameter label/values. These are parameters that need to be passed to the scripts (e.g., the projection).

NOTE: The BlueMarble testdata tarball (BLUEMARBLE_1.8_SPA_1.8_testdata.tar.gz) contains several example test scripts that execute the BlueMarble operations. These scripts will be pointed out in the following subsections. One simple way to execute BlueMarble operations from the directory of your choice using your own data is to copy the example scripts available in the testscripts directory to the selected directory. Change the values of the variables that reflect the file paths of the scripts and the input/output files. Then modify the input/output file name variables. Run the scripts to process your data.

NOTE: The time required for successful execution of the BlueMarble scripts depend on the speed of your computer. If execution fails, you will see an error message indicating the cause of failure (e.g., a file cannot be found, or a label cannot be recognized). Correct it and run again. If the problem has some other cause, it can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with

stdfile* and errfile* and can be deleted after execution. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However, it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. The scripts can be executed from any directory the user chooses. This can be done by prefixing it with the file path for the script.

10.1 Creating Swath/ROIVIIRS True Color Geotiffs

Swath or ROIVIIRS True Color image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/viirs_truecolor.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
cviirsm	Pattern to use to find VIIRS Moderate Resolution Corrected Reflectance Products for processing **within quotes** e.g., "../testdata/input/CVIIRSM_npp_d20130 323*" **The VIIRS Imagery Resolution Corrected Reflectance Product should be in the same directory.** The VIIRS Moderate and Imagery Resolution Corrected Reflectance Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The CVIIRS_SPA can be used to create this product. Real time VIIRS Moderate and Imagery Resolution Corrected Reflectance products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/ The file name patterns for the Corrected Reflectance products are CVIIRSX_npp _dyyyymmdd_thhmmssS_ehhmmssS*.hdf Where X is either 'M' for the moderate resolution product or 'I' for the imagery resolution product;yyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath.
geodir	Path to the directory containing the VIIRS Imagery Resolution Terrain Corrected Geolocation (GITCO) Products corresponding to the Corrected Reflectance products. The VIIRS Imagery Resolution Terrain Corrected Geolocation (GITCO) Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The C-SDR_SPA can be used to create this product. Real time GITCO products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level1/GIT CO_npp_dyyyymmdd_thhmmssS_ehhmmssS*.h5 where yyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. VIIRS Imagery Resolution Terrain Corrected

Projection labels	Description
projection, resolution[Optional]	'projection' can be either (a) geographic or (b) stereographic. When not used, it defaults to 'stereographic' 'resolution' is used to specify the resolution in projection space for the output image product. When using the geographic projection, resolution should be specified in degrees. When using the stereographic projection, resolution should be specified in meters. When not used the 'resolution' parameter defaults to 375m for stereographic and 0.00375 degrees for geographic projections.

Region-Of-Interest Labels	Description
centerlat, centerlon, height, width [Optional]	These four parameters define the Region-Of-Interest. 'centerlat' and 'centerlon' represent the center of the ROI used in output image product. They should be specified in latitude/longitude degrees. For stereographic images, this point also represents the center of projection. The 'height' and 'width' parameters are used to specify the north-south and east-west extents of the ROI respectively. For stereographic projections, 'height' and 'width' are to be specified in km. For geographic projections, the 'height' and 'width' are to be specified in latitude/longitude degrees. The ROI parameters are optional; If not provided, swath imagery will be produced for all matching inputs specified using the 'cviirsm' label.

Output File Labels	Description
outdir	The directory where output imagery will be produced. The directory, if it exists should be empty. Otherwise the script will create the directory as long as the path to it is valid. When the ROI labels are used, the 'outdir' directory will contain ROI subset imagery for each input that overlaps with the specified ROI and the final mosaiced image created by compositing all the component subset images from each overlapping input. When ROI labels are not used, the 'outdir' will contain swath imagery for each matching input. The output image files will be automatically time-stamped. Swath/ROI-subset images will be named as VTCLR_dyyyymmdd_thhmmssS_ehhmmssS.tifwhereyyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm,

		Geolocation products for other locations and times are available for download at www.class.noaa.gov

	ss, S represents the end time of the swath. Mosaiced composite images will be named as MOSAIC_VTCLR_dyyyymmdd_thhmmssS_dyyyymmdd_ehhmmssS.tifwhere the first date/time field represents the start time of the first matching input and the second date/time label represents the end time of the last matching input.

The following script shows an example of a command line to generate VIIRS ROI imagery from the testscripts directory:

```
$ ../algorithm/DRL_scripts/viirs_truecolor.sh \
cviirsm "../testdata/input/viirsinput/CVIIRSM_npp_d20130323*" \
geodir ../testdata/input/viirsinput \
outdir ../testdata/output/viirsoutput2 \
    projection stereographic resolution 375 \
centerlat 23.25 centerlon -82.0 width 1000 height 1000
```

A successful execution requires about 3 minutes or more depending on the speed of your computer.

NOTE: Swath imagery can be produced simply by not providing the ROI labels on the command line. No mosaicing will be performed when creating swath imagery. A warning indicating that mosaicing will not be performed when you do not provide ROI labels on the command line is thus expected.

NOTE: The 'run-BlueMarble_viirs-tcolor.sh' script within the testscripts subdirectory provide a command line example for creating ROI imagery. Warnings about previous and next files being missing are expected. BlueMarble does not find them because they are not included in the testdata tarball.

10.2 Creating Swath/ROIMODIS True Color Geotiffs

Swath or ROI MODIS True Color image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/modis_truecolor.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
modisl1b1km	Pattern to use to find MODIS Level 1B 1km products for processing **within quotes** e.g.,"../testdata/input/MYD021KM.1431 4*" **The MODIS 500m L1B Calibrated**	1. The MODISL1DB_SPA can be used to create these products. 2. Real time MODIS Level 1B products and MODIS Geolocation products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>

Geolocated Radiances, the 250m L1B Calibrated Geolocated Radiances and the MODIS Geolocation products must be in the same directory as the Level 1B 1km files. The MODIS Level 1B and Geolocation products **must conform to either the IPOPP or the DAAC file-naming conventions** described in the Source column to allow BlueMarble to find them.	/modis/level1/. The filename patterns for the 1km L1B, 500m L1B, 250m L1B and the Geolocation product areM*X*D021KM.yyDDDhhmmss.hdf, M*X*D02HKM.yyDDDhhmmss.hdf, M*X*D02QKM.yyDDDhhmmss.hdf and M*X*D03.yyDDDhhmmss.hdf respectively; where *X* is either 'O' for Terra or 'Y' for Aqua and yy, DDD, hh, mm, ss represents the two digit year, day of the year, hour, minutes and seconds respectively for the start of the swath. 3. 5-minute MODIS L1B and MODIS geolocation products for other locations and times are available for download at http://reverb.echo.nasa.gov/reverb/ The DAAC file naming convention specified as follows is also supported in BlueMarble: MXD021KM.AyyyyDDD.hhmm.*.hdf MXD02HKM.AyyyyDDD.hhmm.*.hdf MXD02QKM.AyyyyDDD.hhmm.*.hdf MXD03.AyyyyDDD.hhmm.*.hdf where *X* is either 'O' for Terra or 'Y' for Aqua and yyyy, DDD, hh, mm, represents the four digit year, day of the year, hour, and minutes respectively for the start of the swath.

Projection labels	Description
projection, resolution [Optional]	'projection' can be either (a) geographic or (b) stereographic. When not used, it defaults to 'stereographic' 'resolution' is used to specify the resolution in projection space for the output image product. When using the geographic projection, resolution should be specified in degrees. When using the stereographic projection, resolution should be specified in meters. When not used the 'resolution' parameter defaults to 250m for stereographic and 0.00250 degrees for geographic projections.

Region-Of-Interest Labels	Description
centerlat, centerlon, height, width [Optional]	These four parameters define the ROI. 'centerlat' and 'centerlon' represent the center of the ROI used in output image product. They should be specified in latitude/longitude degrees. For stereographic images, this point also represents the center of projection. The 'height' and 'width' parameters are used to specify the north-south and east-west extents of the ROI respectively. For stereographic projections, 'height' and 'width' are to be specified in

Output File Labels	Description
	km. For geographic projections, the 'height' and 'width' are to be specified in latitude/longitude degrees. The ROI parameters are optional; if not provided, swath imagery will be produced for all matching inputs specified using the 'modisl1b1km' label.
Output File Labels	**Description**
outdir	The directory where output imagery will be produced. The directory, if it exists should be empty. Otherwise the script will create the directory as long as the path to it is valid. When the ROI labels are used, the 'outdir' directory will contain ROI subset imagery for each input that overlaps with the specified ROI and the final mosaiced image created by compositing all the component subset images from each overlapping input. When ROI labels are not used, the 'outdir' will contain swath imagery for each matching input. The output image files will be automatically time-stamped. Swath/ROI-subset images will be named as MXDTCLR_s<startdatetimestamp>_e<enddatetimestamp>.tifwhereX is either 'O' for Terra or 'Y' for Aqua and the datetimestampformatis in the same convention as the input file. Mosaiced composite images will be named as MOSAIC_MXDTCLR_O<start-date/time-stamp>-<end-date/time-stamp>_Y<start-date/time-stamp>-<end-date/time-stamp>.tifwhere the first date/time stamp pair represents the start time of the first and last matching Terra L1B files, while the second date/time stamp pair represents the same for Aqua L1B files. One of the date/time stamp pairs will be absent if only data from one platform is processed.

The following script shows an example of a command line to generate MODIS mosaiced True Color Image for an ROI from the testscripts directory:

```
$ ../algorithm/DRL_scripts/modis_truecolor.sh \
    modisl1b1km "../testdata/input/modisinput/MYD021KM.A2015299*" \
outdir ../testdata/output/modisoutput2/ \
    projection geographic resolution 0.00250 \
centerlat 31.0 centerlon -118.0 width 8 height 8
```

A successful execution requires about 5 minutes or more depending on the speed of your computer.

NOTE: Swath imagery can be produced simply by not providing the ROI labels on the command line. No mosaicing will be performed when creating swath imagery. A warning about mosaicing not to be performed when you do not provide ROI labels on the command line is thus expected.

NOTE: The 'run-BlueMarble_modis-tcolor.sh' and the 'run-BlueMarble_modis-tcolor-swath.sh' scripts within the testscripts subdirectory provide command line examples for creating ROI and swath imagery respectively.

NOTE: The 'modis_truecolor.sh' script supports multi-platform MODIS mosaicing. Place the Aqua   and   Terra   L1B   files   in   the   same   directory   and   use   "<path-to-L1B-

dir>//M[O,Y]D021KM*"for the 'modisl1b1km' label.

10.3 Creating Swath/ROI VIIRS Natural Color Geotiffs

Swath or ROI VIIRS Natural Color (SWIR/NIR/Red False Color RGB) image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/viirs_ncolor.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
cviirsi	Pattern to use to find VIIRS Imagery Resolution Corrected Reflectance Products for processing **within quotes** e.g., "../testdata/input/CVIIRSI_npp_d20130323*" The VIIRS Imagery Resolution Corrected Reflectance Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The CVIIRS_SPA can be used to create this product. Real time VIIRS Imagery Resolution Corrected Reflectance products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/ The file name patterns for the Imagery resolution Corrected Reflectance products are CVIIRSI_npp _dyyyymmdd_thhmmssS_ehhmmssS*.hdf Where yyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath.
geodir	Path to the directory containing the VIIRS Imagery Resolution Terrain Corrected Geolocation (GITCO) Products corresponding to the Corrected Reflectance products. The VIIRS Imagery Resolution Terrain Corrected Geolocation (GITCO)Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The C-SDR_SPA can be used to create this product. Real time GITCO products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level1/GITCO_npp_dyyyymmdd_thhmmssS_ehhmmssS*.h5 where yyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. VIIRS Imagery Resolution Terrain Corrected Geolocation products for other locations and times are available for download at www.class.noaa.gov
Projection labels	Description	
projection,	'projection' can be either (a) geographic or (b) stereographic. When not used, it defaults to	

resolution [Optional]	'stereographic'. 'resolution' is used to specify the resolution in projection space for the output image product. When using the geographic projection, resolution should be specified in degrees. When using the stereographic projection, resolution should be specified in meters. When not used the 'resolution' parameter defaults to 375m for stereographic and 0.00375 degrees for geographic projections.
Region-Of-Interest Labels	**Description**
centerlat, centerlon, height, width [Optional]	These four parameters define the Region-Of-Interest. 'centerlat' and 'centerlon' represent the center of the ROI used in output image product. They should be specified in latitude/longitude degrees. For stereographic images, this point also represents the center of projection. The 'height' and 'width' parameters are used to specify the north-south and east-west extents of the ROI respectively. For stereographic projections, 'height' and 'width' are to be specified in km. For geographic projections, the 'height' and 'width' are to be specified in latitude/longitude degrees. The ROI parameters are optional; if not provided, swath imagery will be produced for all matching inputs specified using the 'cviirsi' label.
Output File Labels	**Description**
outdir	The directory where output imagery will be produced. The directory, if it exists should be empty. Otherwise the script will create the directory as long as the path to it is valid. When the ROI labels are used, the 'outdir' directory will contain ROI subset imagery for each input that overlaps with the specified ROI and the final mosaiced image created by compositing all the component subset images from each overlapping input. When ROI labels are not used, the 'outdir' will contain swath imagery for each matching input. The output image files will be automatically time-stamped. Swath/ROI-subset images will be named as VNCLR_dyyyymmdd_thhmmssS_ehhmmssS.tifwhereyyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. Mosaiced composite images will be named as MOSAIC_VNCLR_dyyyymmdd_thhmmssS_dyyyymmdd_ehhmmssS.tifwhere the first date/time field represents the start time of the first matching input and the second date/time label represents the end time of the last matching input.

The following script shows an example of a command line to generate VIIRS ROI imagery from the testscripts directory:

```
$ ../algorithm/DRL_scripts/viirs_ncolor.sh \
cviirsi "../testdata/input/viirsinput/CVIIRSI_npp_d20130323*" \
```

```
geodir ../testdata/input/viirsinput \
outdir ../testdata/output/viirsncoloroutput2 \
   projection stereographic resolution 375 \
centerlat 23.25 centerlon -82.0 width 1000 height 1000
```

A successful execution requires about 3 minutes or more depending on the speed of your computer.

NOTE: Swath imagery can be produced simply by not providing the ROI labels on the command line. No mosaicing will be performed when creating swath imagery. A warning indicating that mosaicing will not be performed when you do not provide ROI labels on the command line is thus expected.

NOTE: The 'run-BlueMarble_viirs-ncolor.sh' script within the testscripts subdirectory provides a command line example for creating ROI imagery. Warnings about previous and next files being missing are expected. BlueMarble does not find them because they are not included in the testdata tarball.

10.4 Creating Swath/ROI MODIS Natural Color Geotiffs

Swath or ROI MODIS Natural Color (SWIR/NIR/Red False Color RGB) image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/modis_ncolor.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
modisl1b1km	Pattern to use to find MODIS Level 1B 1km products for processing **within quotes** e.g.,"../testdata/input/MYD021KM.14314*" **The MODIS 500m L1B Calibrated Geolocated Radiances, the 250m L1B Calibrated Geolocated Radiances and the MODIS Geolocation products must be in the same directory as the Level 1B 1km files.** The MODIS Level 1B and Geolocation products **must conform to either the IPOPP or the DAAC file-naming conventions** described in the Source column to allow BlueMarble to find them.	1. The MODISL1DB_SPA can be used to create these products. 2. Real time MODIS Level 1B products and MODIS Geolocation products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level1/. The filename patterns for the 1km L1B, 500m L1B, 250m L1B and the Geolocation product are MXD021KM.yyDDDhhmmss.hdf, MXD02HKM.yyDDDhhmmss.hdf, MXD02QKM.yyDDDhhmmss.hdf and MXD03.yyDDDhhmmss.hdf respectively; where X is either 'O' for Terra or 'Y' for Aqua and yy, DDD, hh, mm, ss represents the two digit year, day of the year, hour, minutes and seconds respectively for the start of the swath. 3. 5-minute MODIS L1B and MODIS geolocation

	products for other locations and times are available for download at http://reverb.echo.nasa.gov/reverb/ The DAAC file naming convention specified as follows is also supported in BlueMarble: MXD021KM.AyyyyDDD.hhmm.*.hdf MXD02HKM.AyyyyDDD.hhmm.*.hdf MXD02QKM.AyyyyDDD.hhmm.*.hdf MXD03.AyyyyDDD.hhmm.*.hdf where *X* is either 'O' for Terra or 'Y' for Aqua and yyyy, DDD, hh, mm, represents the four digit year, day of the year, hour, and minutes respectively for the start of the swath.

Projection labels	Description
projection, resolution[Optional]	'projection' can be either (a) geographic or (b) stereographic. When not used, it defaults to 'stereographic' 'resolution' is used to specify the resolution in projection space for the output image product. When using the geographic projection, resolution should be specified in degrees. When using the stereographic projection, resolution should be specified in meters. When not used the 'resolution' parameter defaults to 250m for stereographic and 0.00250 degrees for geographic projections.

Region-Of-Interest Labels	Description
centerlat, centerlon, height, width [Optional]	These four parameters define the ROI. 'centerlat' and 'centerlon' represent the center of the ROI used in output image product. They should be specified in latitude/longitude degrees. For stereographic images, this point also represents the center of projection. The 'height' and 'width' parameters are used to specify the north-south and east-west extents of the ROI respectively. For stereographic projections, 'height' and 'width' are to be specified in km. For geographic projections, the 'height' and 'width' are to be specified in latitude/longitude degrees. The ROI parameters are optional; if not provided, swath imagery will be produced for all matching inputs specified using the 'modisl1b1km' label.

Output File Labels	Description
outdir	The directory where output imagery will be produced. The directory, if it exists should be empty. Otherwise the script will create the directory as long as the path to it is valid. When the ROI labels are used, the 'outdir' directory will contain ROI subset imagery for each

	input that overlaps with the specified ROI and the final mosaiced image created by compositing all the component subset images from each overlapping input.
	When ROI labels are not used, the 'outdir' will contain swath imagery for each matching input.
	The output image files will be automatically time-stamped. Swath/ROI-subset images will be named as MXDNCLR_s<startdatetimestamp>_e<enddatetimestamp>.tifwhereX is either 'O' for Terra or 'Y' for Aqua and the datetimestamp format matches the date/time stamp convention of the input files. Mosaiced composite images will be named as MOSAIC_MXDNCLR_O<start-date/time-stamp>-<end-date/time-stamp>_Y<start-date/time-stamp>-<end-date/time-stamp>.tif where the first date/time stamp pair represents the start time of the first and last matching Terra L1B files, while the second date/time stamp pair represents the same for Aqua L1B files. One of the date/time stamp pairs will be absent if only data from one platform is processed.

The following script shows an example of a command line to generate a MODIS mosaicked Natural Color Image for an ROI from the testscripts directory:

```
$ ../algorithm/DRL_scripts/modis_ncolor.sh \
   modisl1b1km "../testdata/input/modisinput/MYD021KM.A2015299*" \
outdir ../testdata/output/modisncoloroutput2/ \
   projection geographic resolution 0.00250 \
centerlat 33.96 centerlon -115.61 width 3 height 3
```

A successful execution requires about 2 minutes or more depending on the speed of your computer.

NOTE: Swath imagery can be produced simply by not providing the ROI labels on the command line. No mosaicing will be performed when creating swath imagery. A warning indicating that mosaicing will not be performed when you do not provide ROI labels on the command line is thus expected.

NOTE: The 'run-BlueMarble_modis-ncolor.sh' script within the testscripts subdirectory provides a command line example for creating ROI imagery.

NOTE: The 'modis_ncolor.sh' script supports multi-platform MODIS mosaicing. Place the Aqua and Terra L1B files in the same directory and use "<path-to-L1B-dir>//M{O,Y}D021KM*"for the 'modisl1b1km' label.

10.5 Creating Swath/ROI VIIRS ENCC Day/Night Geotiffs

Swath or ROI VIIRS ENCC Day/Night image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/viirs_encc.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
encc	Pattern to use to find VIIRS ENCC products for processing **within quotes,** e.g.,"../testdata/input/ENCC.17166*"	The ENCC_SPA can be used to create this product. Please contact the DRL for additional information regarding the ENCC SPA.

Projection labels	Description
projection, resolution[Optional]	'projection' can be either (a) geographic or (b) stereographic. When not used, it defaults to 'stereographic' 'resolution' is used to specify the resolution in projection space for the output image product. When using the geographic projection, resolution should be specified in degrees. When using the stereographic projection, resolution should be specified in meters. When not used the 'resolution' parameter defaults to 750m for stereographic and 0.0075 degrees for geographic projections.

Region-Of-Interest Labels	Description
centerlat, centerlon, height, width [Optional]	These four parameters define the ROI. 'centerlat' and 'centerlon' represent the center of the ROI used in output image product. They should be specified in latitude/longitude degrees. For stereographic images, this point also represents the center of projection. The 'height' and 'width' parameters are used to specify the north-south and east-west extents of the ROI respectively. For stereographic projections, 'height' and 'width' are to be specified in km. For geographic projections, the 'height' and 'width' are to be specified in latitude/longitude degrees. The ROI parameters are optional; if not provided, swath imagery will be produced for all matching inputs specified using the 'vncco' label.

Other Label	Description
select [Optional]	'select' can be used to select input products from a particular time of the day. It can take any of the three following values: 'day', 'twilight', 'night'. (Note 'night' will include 'twilight' inputs.) If not used, image generation will include all matching input ENCC products.

Output File Labels	Description
outdir	The directory where output imagery will be produced. The directory, if it exists should be empty. Otherwise the script will create the directory as long as the path to it is valid. When the ROI labels are used, the 'outdir' directory will contain ROI subset imagery for each input that overlaps with the specified ROI and the final mosaiced image created by compositing

	all the component subset images from each overlapping input.
	When ROI labels are not used, the 'outdir' will contain swath imagery for each matching input.
	The output image files will be automatically time-stamped. Swath/ROI-subset images will be named as ENCC1_yyDDDhhmmss.<DayLabel>.<TwilightLabel>.<NightLabel>.<Ascending-Orbit-Label>.<Descending-Orbit-Label>.tifwhere yy, DDD, hh, mm, and ss represents the 2-digit year, day of the year, hour, minutes, seconds for the start of the swath respectively. <DayLabel> can be either 'DAY' or 'XXX' to indicate whether the input data product includes daytime regions or not respectively. Similarly <TwilightLabel> (either 'TWI' or 'XXX') and <NightLabel> (either 'NGT' or 'XXX') are used to indicate whether the input data product includes twilight or nighttime regions respectively. The <Ascending-Orbit-Label> can be either 'A' or 'X' to indicate whether the input data includes scans from an Ascending orbit or not respectively. Similarly <Descending-Orbit-Label> can be either 'D' or 'X' to indicate whether the input data product includes scans from a Descending orbit or not respectively. Mosaiced composite images will be named as MOSAIC_ENCC1_yyyyDDDhhmmss_yyyyDDDhhmmss.tifwhere the first date/time field represents the start time of the first matching input and the second date/time label represents the end time of the last matching input.

The following script shows an example of a command line to generate VIIRS ROI imagery from the testscripts directory:

```
$ ../algorithm/DRL_scripts//viirs_encc.sh \
encc "../testdata/input/viirsenccinput/ENCC.17*" \
outdir ../testdata/output/viirsenccoutput2 \
centerlat 25.0 centerlon -107.0 \
   height 1000 width 1000
```
A successful execution requires about 1 minute or more depending on the speed of your computer.

NOTE: Swath imagery can be produced simply by not providing the ROI labels on the command line. No mosaicing will be performed when creating swath imagery. A warning about mosaicing not to be performed when you do not provide ROI labels on the command line is thus expected.

NOTE: The 'run-BlueMarble_viirs-encc.sh' script within the testscripts subdirectory provides a command line example for creating ROI imagery. Warnings stating that previous and next files are missing are expected. BlueMarble does not find them because they are not included in the testdata tarball.

10.6 Creating OMPS-SO2 Overlays on BlueMarble Geotiffs

OMPS-SO2 Overlays on BlueMarble geotiff products can be created by executing the following script:

    SPA/BlueMarble/algorithm/DRL_scripts/omps_so2_vtcolor.sh [label value pairs]

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
ingeotiff	Path to the input background geotiff.	1. The image generation scripts in BlueMarble (as described in previous sections) can be used to create the input geotiff) 2. Real time Sharpened True Color, Natural Color and ENCC geotiffs over the eastern US region are available from the DRL ftp site: For VIIRS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSTCOLOR_roi1.yyDDDhhmmss.tif For VIIRS Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSNCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPTCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPNCOLOR_roi1.yyDDDhhmmss.tif For VIIRS ENCC: Please contact the DRL for additional information regarding the ENCC SPA.
ompsso2	Pattern to use to find OMPS SO2 Level 2 HDF products for processing **within quotes,** e.g., "../testdata/input/ompsl2input/OMPS-NPP-TC_EDR_SO2NRT-2016m0519*" The OMPS SO2 Level 2 HDF Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The OMPSNADIR_SPA (v2.0.1b+) can be used to create this product. Real-time OMPS SO2 Level 2 HDF products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/omps/level2 The file name patterns for the OMPS SO2 Level 2 HDF products are OMPS-NPP-TC_EDR_SO2NRT-yyyymMMddthhmmss*.he5 Where yyyy, MM, dd, hh, mm, ss represent the year, month, day of month, hour, minutes, and seconds for the start of the swath respectively.

SO2 Field Selection	Descriptions
so2field	The parameter allows the user to choose the SO2 field. The values can be one of the following: 'PBL' - Planetary Boundary Layer 'TRL' - Lower Troposphere 'TRM' - Mid Troposphere (default) 'STL' - Upper Tropospheric and Stratospheric 'PBLbrd' - Planetary Boundary Layer (Band Residual Difference algorithm) 'STLbrd' - Upper Tropospheric and Stratospheric (Band Residual Difference algorithm) 'TRMbrd' - Mid Troposphere (Band Residual Difference algorithm)

Overlay controlling Parameters	Description
min, max [optional]	The 'min', 'max' parameters are used to specify the range of the SO$_2$ level to show on the image in D.U. units. The default 'min', 'max' are 0.0 and 2.0 D.U. respectively.
filtersize [optional]	The 'filtersize' parameter is used to control the smoothing level of the overlay. You can use values between 1 and 50 where 1 means no smoothing (best representation of original data) and 50 is the maximum smoothing. The default is 15. Smoothing is achieved by subjecting the data to a mean filter, and a higher filtersize implies more averaging and thus more deviation from the original OMPS data. Our utility includes a technique to upscale OMPS data to a higher resolution before the filtering. This allows higher filtersizes to work much better. A filtersize of 15 (the default) is recommended to provide the best balance between the underlying data and image quality.
dissolve [optional]	The 'dissolve' parameter (0 to 100) is used to control the transparency of the overlay. You can use values between 0 and 100; where 0 means completely transparent and 100 means fully opaque. The default is 60.

Output File Labels	Description
output	Path to the output OMPS-SO2-Overlay geotiff image. The overlay will be created by searching the input set for OMPS products that overlap the region represented by the background geotiff and then using them to overlay the SO2 values on the background. Legends will be automatically created at the same location. The legend image will be named as <Output-Geotiff-Filename>_LEGEND.png.

The following script shows an example of a command line to generate an OMPS-SO2-overlay geotiff from the testscripts directory:

```
$ ../algorithm/DRL_scripts//omps_so2_vtcolor.sh \
   ingeotiff ../testdata/input/ompsl2input/MOSAIC_VTCLR_STER1KM_d20160519_t1839440_d20160519_e1844000.tif \
   ompsso2 "../testdata/input/ompsl2input/OMPS-NPP-TC_EDR_SO2NRT-2016m0519*" \
   output ../testdata/output/OMPSSO2_VTCOLOR_2016m0519.tif \
   min 0.25 max 2.0
```

A successful execution requires a few seconds or more depending on the speed of your

computer.

NOTE: The 'run-BlueMarble_omps-so2-viirs-tcolor.sh'script within the testscripts subdirectory provides a command line example for overlaying OMPS SO$_2$ on previously created background geotiff imagery.

NOTE: A 'filtersize' of 1 (i.e., no smoothing) will be used if one of the OMPS datasets used to create the overlay product spans the polar region, irrespective of what was provided on the command line.

10.7 Creating OMPS-Aerosol Overlays on BlueMarble Geotiffs

OMPS Aerosol Overlays on BlueMarble Geotiff image products can be created by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/omps_aerosol_vtcolor.sh [label value pairs] …

The following table contains labels, and their descriptions, required by the script.

Input File Labels	Description	Source
ingeotiff	Path to the input background geotiff.	1. The image generation scripts in BlueMarble (as described in previous sections) can be used to create the input geotiff) 2. Real time Sharpened True Color, Natural Color and ENCC geotiffs over the eastern US region are available from the DRL ftp site: For VIIRS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSTCOLOR_roi1.yyDDDhhmmss.tif For VIIRS Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSNCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPTCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPNCOLOR_roi1.yyDDDhhmmss.tif For VIIRS ENCC:

		Please contact the DRL for more information regarding the ENCC SPA.
ompsaerosol	Pattern to use to find OMPS Total Column Total Ozone Level 2 HDF products for processing **within quotes,** e.g., "../testdata/input/ompsl2input/OMPS-NPP-TC_EDR_TO3-v1.0-2016m0519*" The OMPS Total Column Total Ozone Level 2 HDF Products **must conform to the file-naming convention** described in the Source column to allow BlueMarble to find them.	The OMPSNADIR_SPA (v2.0.1b or later) can be used to create this product. Real-time OMPS Total Column Total Ozone Level 2 HDF products over the eastern US region are available from the DRL ftp site at: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/omps/level2 The file name patterns for the OMPS SO2 Level 2 HDF products are OMPS-NPP-TC_EDR_TO3-v1.0-yyyymMMddthhmmss*.h5 Where yyyy, MM, dd, hh, mm, ss represent the year, month, day of month, hour, minutes, and seconds for the start of the swath respectively.

Overlay controlling Parameters	Description
min, max [optional]	The 'min', 'max' parameters are used to specify the range of the Aerosol Index levels to show on the image. The default 'min', 'max' are 1.0 and 3.0 respectively.
filtersize [optional]	The 'filtersize' parameter is used to control the smoothing level of the overlay. You can use values between 1 and 50 where 1 means no smoothing (best representation of original data) and 50 is the maximum smoothing. The default is 15. Smoothing is achieved by subjecting the data to a mean filter, and a higher filtersize implies more averaging and thus more deviation from the original OMPS data. Our utility includes a technique to upscale OMPS data to a higher resolution before the filtering. This allows higher filtersizes to work much better. A filtersize of 15 (the default) is recommended to provide the best balance between the underlying data and image quality..
dissolve [optional]	The 'dissolve' parameter (0 to 100) is used to control the transparency of the overlay. You can use values between 0 and 100; where 0 means completely transparent and 100 means fully opaque. The default is 60.
Output File Labels	**Description**
output	Path to the output OMPS-Aerosol-Overlay geotiff image. The overlay will be created by searching the input set for OMPS products that overlap the region represented by the background geotiff and then using them to overlay the Aerosol values on the background. Legends will be automatically created at the same location. The legend image will be named as <Output-Geotiff-Filename>_LEGEND.png.

The following script shows an example of a command line to generate OMPS-Aerosol-Overlay Geotiff imagery from the testscripts directory:

```
$ ../algorithm/DRL_scripts//omps_aerosol_vtcolor.sh \
   ingeotiff ../testdata/input/ompsl2input/MOSAIC_VTCLR_STER1KM_d20160519_t1839440_d20160519_e1844000.tif \
   ompsaerosol "../testdata/input/ompsl2input/OMPS-NPP-TC_EDR_TO3-v1.0-2016m0519*" \
   output ../testdata/output/OMPSAEROSOL_VTCOLOR_2016m0519.tif \
min 1.0 max 3.0
```

A successful execution requires a few seconds or more depending on the speed of your computer and the size of your input.

NOTE: The 'run-BlueMarble_omps-aerosol-viirs-tcolor.sh' script within the testscripts subdirectory provides a command line example for overlaying OMPS Aerosol on previously created background geotiff imagery.

NOTE: A 'filtersize' of 1 (i.e., no smoothing) will be used if one of the OMPS datasets used to create the overlay product spans the polar region, irrespective of what was provided on the command line.

10.8 Overlaying Fire Pixels on BlueMarble Geotiffs

Fire pixels can be overlaid on a geotiff created by the above scripts by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/overlay_fires.sh [label value pairs] …

The following table contains labels, and their descriptions, required by this script.

Input File Labels	Description	Source
fireloc	Pattern to use to find fire location text files **within quotes,** e.g.,"../testdata/input/viirsinput/Fireloc_npp_d20130323*"	1. The MOD14_SPA, the VIIRS-AF_SPA and the VFIRE375_SPA can be used to create fire location text files for MODIS and VIIRS respectively. 2. Real time Fire Location Text Files over the eastern US region are available from the DRL ftp site at: VIIRS-AF_SPA fire location files: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/FireLoc_npp_dyyyymmdd_thhmmssS_ehhmmssS*.txt VFRIRE375_SPA: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/FireLoc375_npp_dyyyymmdd_thhmmssS_ehhmmssS*.txt

		where yyyy, mm, dd represents the year, month, and day of month for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. MOD14_SPA: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXD14.yyDDDhhmmss.txt where *X* is either 'O' for Terra or 'Y' for Aqua and yy, DDD, hh, mm, ss represents the two digit year, day of the year, hour, minutes and seconds respectively for the start of the swath.
ingeotiff	Path to the input background geotiff.	1. The image generation scripts in BlueMarble (as described in previous sections) can be used to create the input geotiff. 2. Real time Sharpened True Color, Natural Color and ENCC geotiffs over the eastern US region are available from the DRL ftp site at: For VIIRS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSTCOLOR_roi1.yyDDDhhmmss.tif For VIIRS Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSNCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPTCOLOR_roi1.yyDDDhhmmss.tif For MODIS Sharpened Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/modis/level2/MXDSHARPNCOLOR_roi1.yyDDDhhmmss.tif For VIIRS ENCC: Please contact the DRL for more information regarding the ENCC SPA.ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/ENCC_roi1.yyDDDhhmmss.<DayLabel>.<TwilightLabel>.<NightLabel>.<AscendingOrbit-Label>.<Descending-Orbit-Label>.tif

Fire Location Type Selection	Description
fireloctype	Use 'confidence' when input fire location text files are from MOD14_SPA or VIIRS-AF_SPA. Use 'firemask' when the input fire location text files are from VFIRE375_SPA. The default is 'confidence'

Parameter labels	Description
markertype [optional]	'markertype' can be used to specify the shape of the marker used to mark the fire pixels on the output geotiff. It can be 'square' , 'circle' or 'none'. When 'none' is used, fire pixels are not overlaid; this value may be useful if you wish to overlay only the perimeter. When the parameter is not used at all, it defaults to 'square'.
markersize[Optional]	'markersize' can be used to specify the size of squares or circles designating the fire pixels on the output geotiff. It can be either (a) 'small' or (b) 'medium' or (c) 'large'. When not used, it defaults to 'medium'.
markerfill [Optional]	'markerfill' can be either 'filled' or 'hollow' and is used to indicate whether the marker is filled or hollow. When not used, it defaults to 'filled'.
perimeter [Optional]	'perimeter' can be either 'true' or 'false'. The default is 'false'. When set to true, fire pixels are clustered based on proximity to each other (see 'clusterradius' below), a perimeter is computed for each cluster (with at least two fire pixels) and the computed perimeters are overlaid on the geotiff. This is an Alpha feature.
clusterradius [Optional]	This parameter is used to control the clustering algorithm for determining the fire-pixel-clusters and their perimeters. It is the square of the distance (in pixel size units) between two pixels and is a measure of how close fire-pixels have to be to each other in order to belong to the same cluster. The default is 10.

Output File Labels	Description
outgeotiff	The path to the output geotiff. This geotiff will have fire locations (extracted from the matching fire location text files) and fire perimeters (if requested) overlaid on it. The fire pixels will be color-indexed based on the fire detection confidence (Red: high confidence; Orange: medium confidence; Yellow: low confidence).

The following script shows an example of a command line for overlaying fires to execute from the testscripts directory:

```
$ ../algorithm/DRL_scripts/overlay_fires.sh \
fireloc "../testdata/input/viirsinput/Fireloc_npp_d20130323*" \
ingeotiff ../testdata/input/viirsinput/MOSAIC_VTCLR_d20130323_t1850298_d20130323_e1854430.tif \
outgeotiff ../testdata/output//MOSAIC_VTCLRFIRE_d20130323_t1850298_d20130323_e1854430.tif \
markersize small \
perimeter true
```

A successful execution requires about 1 second or more depending on the speed of your computer.

NOTE: The 'run-BlueMarble_modis-fireoverlay.sh' script within the testscripts subdirectory provides a command line example for overlaying fire locations extracted from the MOD14_SPA fire location text files. The 'run-BlueMarble_viirstcolor-fireoverlay.sh' script within the testscripts subdirectory provides a command line example for overlaying fire locations extracted from the VIIRS-AF_SPA fire location text files.

NOTE: The fire overlaying utility will overlay all fires from the matching fire location text files specified with the 'fireloc 'label as long as they are within the spatial extent of the input geotiff. It does not discard fire pixels if they do not correspond to the temporal period represented by the input geotiff. While this gives users the flexibility of mixing and matching geotiffs and fire location text files from different sensors and temporal periods, users will need to be mindful of what fire location text files they are overlaying.

10.9 Overlaying Vector Shapefiles on BlueMarble Geotiffs

Shapefiles can be overlaid on a geotiff created by the above scripts by executing the following script:

SPA/BlueMarble/algorithm/DRL_scripts/overlay_shapefile.sh [label value pairs] …

The following table contains labels, and their descriptions, required by this script.

Input File Labels	Description	Source
shapefile	Path to the shapefile.	There are multiple shapefiles included in this package under algorithm/shapefileoverlay/shapefiles. The shapefiles are organized in a self-explanatory directory/filename structure.
ingeotiff	Path to the input geotiff.	1. The image generation scripts in BlueMarble (as described in previous sections) can be used to create the input geotiff. 2. Real time Sharpened True Color, Natural Color and ENCC geotiffs over the eastern US region are available from the DRL ftp site at: For VIIRS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSTCOLOR_roi1.yyDDDhhmmss.tif For VIIRS Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSNCOLOR_roi1.yyDDDhhmmss.tif

		For MODIS Sharpened True Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/ modis/level2/MXDSHARPTCOLOR_roi1.yyDD Dhhmmss.tif For MODIS Sharpened Natural Color: ftp://is.sci.gsfc.nasa.gov/gsfcdata/<terra|aqua>/ modis/level2/MXDSHARPNCOLOR_roi1.yyDD Dhhmmss.tif For VIIRS ENCC: Please contact the DRL for more information regarding the ENCC SPA.ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs /level2/ENCC_roi1.yyDDDhhmmss_<DayLabel >.<TwilightLabel>.<NightLabel>.<AscendingOr bit-Label>.<Descending-Orbit-Label>.tif

Parameter labels	Description
color [Optional]	'color' is used to specify the desired color of the vector overlay lines. 'color' can be 'red', 'green', 'blue', 'yellow', 'cyan', 'magenta', 'black' or 'white'. The default is 'yellow'.
linewidth[Optional]	'linewidth' is used to specify the width of the vector overlay lines. The default is 1.

Output File Labels	Description
outgeotiff	The path to the output geotiff. This geotiff will have vectors from the input shapefiles overlaid on it.

The following script shows an example of a command line for overlaying fires to execute from the testscripts directory:

```
$ ../algorithm/DRL_scripts/overlay_shapefile.sh \
shapefile ../algorithm/module_shapefileoverlay/shapefiles/global/GSHHS_highres_coastlines.shp \
ingeotiff ../testdata/input/viirsinput/MOSAIC_VTCLR_d20130323_t1850298_d20130323_e1854430.tif \
outgeotiff ../testdata/output//MOSAIC_VTCLR_VECTOR_d20130323_t1850298_d20130323_e1854430.tif \
linewidth 1 color yellow
```

A successful execution requires about 1 minute or more depending on the speed of your computer.

NOTE: The 'run-BlueMarble-shapefileoverlay.sh' script within the testscripts subdirectory provides a command line example for overlaying a shapefile.

10.10 Important Notes

- When you override the default stereographic projection, be sure to also specify the resolution label along with the projection label. Care should be taken while specifying the resolution, as the resolution units of the geographic (degrees) and stereographic

(meters) projections are different.

- For VIIRS and MODIS True Color and MODIS Natural Color, the sharpening algorithm is always run, irrespective of the resolution specified. However, benefits of sharpening are most realized when outputs are produced in 250m for MODIS and 375m for VIIRS. Specifying such high resolutions is not however recommended when the Region-Of-Interest is large. In such cases BlueMarble may run out of resources and fail. You may consider increasing the Java heap size in such situations. Please refer to Appendix B, "Modifying Maximum Java Heap Size."

- Geographic projections are not appropriate for very high latitudes. Use 'stereographic' projections for such ROIs.

Installation of this SPA in IPOPP mode will make the SPA services listed in Table A-1 available to IPOPP. These SPA services along with any other prerequisite SPA services (listed in Table A-2) will need to be enabled to allow IPOPP to automate production of the BlueMarble data products. The SPAs containing the prerequisite SPA services listed in Table A-2 can be downloaded from the DRL Web Portal, in case they are not already available in your IPOPP installation. Details about these other SPAs are available in the respective SPA User's Guides. Please refer to the IPOPP User's Guide for instructions on how to install an SPA in IPOPP and enable the corresponding SPA services.

Table A-1. SPA Services

SPA services for this SPA	Data Products produced	
	Product Name	**Destination (when installed in IPOPP)**
BlueMarble_modis-crefltcolor	MODIS Sharpened Corrected Reflectance – True Color Bands	$HOME/drl/data/pub/gsfcdata/<terra|aqua>/modis/level2/M<O|Y>DTCLR_syyDDDhhmmss_eyyDDDhhmmss.hdf[1]
BlueMarble_modis-tcolor	MODIS Sharpened True Color Images	$HOME/drl/data/pub/gsfcdata/<terra|aqua>/modis/level2/M<O|Y>DSHARPTCOLOR_roi<n>.yyDDDhhmmss.tif[1]
BlueMarble_modis-creflncolor	MODIS Sharpened Corrected Reflectance – Natural Color Bands	$HOME/drl/data/pub/gsfcdata/<terra|aqua>/modis/level2/M<O|Y>DNCLR_syyDDDhhmmss_eyyDDDhhmmss.hdf[1]
BlueMarble_modis-ncolor	MODIS Natural Color Images	$HOME/drl/data/pub/gsfcdata/<terra|aqua>/modis/level2/M<O|Y>DSHARPNCOLOR_roi<n>.yyDDDhhmmss.tif[1]
BlueMarble_viirs-encc	ENCC Day/Night Images	$HOME/drl/data/pub/gsfcdata/npp/viirs/level2/ENCC_roi<n>.yyDDDhhmmss.tif[1]
BlueMarble_viirs-crefltcolor	VIIRS Sharpened Corrected Reflectance – True Color Bands	$HOME/drl/data/pub/gsfcdata/npp/viirs/level2/VTCLR_syyDDDhhmmss_eyyDDDhhmmss.hdf[1]
BlueMarble_viirs-tcolor	VIIRS True Color Images	$HOME/drl/data/pub/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSTCOLOR_roi<n>.yyDDDhhmmss.tif[1]
BlueMarble_viirs-ncolor	VIIRS Natural Color Images	$HOME/drl/data/pub/gsfcdata/npp/viirs/level2/NPP_SHARPVIIRSNCOLOR_roi<n>.yyDDDhhmmss.tif[1]

[1] Where *yy*, *DDD*, *hh, mm, ss* represents the 2-digit year, day of year, hour, minute and seconds respectively for the start of swath and where applicable the second yyDDDhhmmss represents the end of the swath. 'n' is the ROI index ('1' for default installs).

Table A-2. Prerequisite SPA Services

For BlueMarble_viirs-crefltcolor, BlueMarble_viirs-tcolor, BlueMarble_viirs-ncolor SPA services:

Prerequisite SPA services	SPA in which they are available
VIIRS_C-SDR (NOAA Format) **or** **VIIRS-L1 and L1toSDR (NASA Format)**	C-SDR_SPA or VIIRS-L1_SPA and L1toSDR_SPA
CVIIRS	CVIIRS_SPA

For BlueMarble_viirs-encc SPA service:

Prerequisite SPA services	SPA in which they are available
VIIRS-L1	VIIRS-L1_SPA
ENCC	ENCC_SPA

For BlueMarble_modis-crefltcolor, BlueMarble_modis-tcolor, BluMarble_modis-creflncolor and BlueMarble_modis-ncolor SPA services:

Prerequisite SPA services	SPA in which they are available
l0l1terra	MODISL1DB_SPA
l0l1aqua	MODISL1DB_SPA
l1atob	MODISL1DB_SPA
gbad	GBAD_SPA

Appendix B
Modifying Maximum Java Heap Size

To increase/decrease maximum Java heap size, cd into algorithm/h2g/bin and open the files h2g.sh,CopyGeotiffTags.sh, OverlayFires.sh, OverlayFireVectors.sh, and OverlayShapeFile.sh. Edit the line '-Xmx4g'or '-Xmx2g'to the required value. For example, to increase it to 6G, edit it to '-Xmx6g'.

CAUTION: Decreasing Java heap size may cause some high-resolution image generations to fail**.**